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RULES

AND THE INSPECTION OF

STEAM BOILERS

1884

ENGINES.

BRITISH COLUMBIA.

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STEAM BOILERS INSPECTION ACT, 1901.

RULES FOR THE INSPECTION

— OF —
THE FIELD HALL STACKS

Steam Boilers and Engines.



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STEAM BOILERS INSPECTION ACT.

PROVINCIAL SECRETARY'S OFFICE,

July, 1913.

HIS HONOUR the Lieutenant-Governor in Council is pleased to direct the publication of the following Rules and Regulations for the inspection of steam-boilers, and all matters connected with the construction and working thereof.

By Command.

HENRY ESSON YOUNG,
Provincial Secretary.

RULES FOR THE INSPECTION OF STEAM BOILERS AND ENGINES.

INTERPRETATION.

SEC. A. In the construction and for the purpose of these rules (if not inconsistent with the context or subject-matter) the following terms shall have the respective meanings hereinafter assigned to them:—

“The Act,” wherever the same occurs in these rules, means the “Boilers Inspection Act”:

“Boiler,” wherever the same occurs in these rules, includes the steam engine or engines, the steam-pipes and connections, and every part thereof, and all apparatus and things attached to and connected therewith, or used with reference to any such boiler or engine:

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“ Steam plant ” means and includes any steam-boiler, steam engine or engines, and all apparatus mentioned in the previous paragraph :

“ Low-pressure heating plant ” means and includes all low - pressure heating boilers where all the water of condensation is returned to the boiler by gravity or by automatic apparatus ; and in the case of steel boilers, where the maximum allowable working - pressure does not exceed thirty pounds per square inch ; or in the case of cast-iron boilers, where it does not exceed five pounds per square inch :

“ Owner ” means and includes any person, firm, or corporation, the owner or lessee of the boiler, and the manager or other chief officer in charge of the business of any such firm or corporation :

“ Engineer ” means any person having charge of or operating a steam-boiler under the provisions of the Act :

“ Chief Inspector ” means a person appointed under the provisions of the Act to inspect boilers and machinery, and to have general supervision over the Inspectors as well as all matters and things in connection with the Act :

“ Inspector ” means any Inspector of Steam-boilers appointed under the Act :

“ Engineer Surveyor ” means any Inspector who is acting in the capacity of supervisor of construction of boilers and machinery under the provision of the Act :

“ Certificate ” means a certificate of inspection given by the Chief Inspector or an Inspector, as the case may be :

“ Horse-power ” means power of boilers calculated as follows : by taking the square feet of heating surface and dividing by fifteen :

“ Built under inspection ” means that the boiler or machinery has been constructed

under the supervision of an Inspector or Engineer Surveyor authorized by the Act:
“Design” means and includes the blue-prints and specifications, specimens, or models submitted to the Chief Inspector for approval and registration:

“Registered design” means a design which has been approved and registered by the Chief Inspector, and includes the blue-prints, specifications, design register sheet, and specimens or models, all of which bear the same serial number:

EXTENT AND APPLICATION OF RULES.

SEC. B. These rules shall apply to all steam-boilers and steam-heating plants operated within the Province, except as hereinafter exempted.

These rules shall not apply to railway locomotives on railways under the supervision of the Dominion, nor to any boiler subject to inspection under the Dominion “Steamboat Inspection Act,” nor to any boiler or steam-heating plant with a capacity of 2 horse-power or under, nor to any steam-heating plants in private residences; but rooming-houses and apartment-houses shall not be considered private residences.

REGISTRATION OF DESIGNS.

SEC. C. (a.) Designs must be submitted to the Chief Inspector of Machinery for all boilers, safety-valves, main stop-valves, blow-off cocks, water-gauge fittings, and test-cocks to be used under the provisions of the Act.

The registration of engines is optional, but the connecting - rods, crank - shafts, piston - rods, fly-wheels, governors, and steam-cylinders must conform to the provisions of the Act and rules, and Inspectors may refuse to pass engines where any part appears to be positively weak or inefficient.

(b.) Before commencing construction of any boiler to be built for operation under the jurisdiction of the British Columbia “Boilers Inspection Act,” complete drawings and specifications on

Forms No. 7, both in triplicate, must be submitted to the Chief Inspector of Machinery for approval of the boiler, together with fee according to scale of charges.

Designs will not be finally passed until they comply in all respects with the Act and rules.

(c.) In cases where boilers are of unusual design and construction, and where a doubt exists as to the direction and magnitude of the stresses, then permission may be given to build one boiler, which is to be subjected to experimental tests by the Department; the expenses connected with such tests to be borne by the manufacturer. The design will be passed when these tests satisfy the Inspectors that the boiler will safely withstand the stresses to which it will be subjected during operation at the steam-pressure allowed:

(d.) When the Chief Inspector has examined the drawings and specifications, he will report to the person by whom the particulars were submitted, in the order in which such applications were received; and when the plans are approved he will send a copy of Forms Nos. 7 and 8, together with drawings, to the Engineer Surveyor in whose district the boiler is to be built. Such Engineer Surveyor must be careful, in making examination from time to time, to see that the drawings and the particulars contained in Forms 7 and 8 are followed during construction; and when the boiler is completed and satisfactorily tested he must report to the Chief Inspector on Form No. 9; when this form has been compared with the office records and entered, he will forward it to the Inspector in whose district the boiler is to be operated.

(e.) Immediately on completion of the boiler the manufacturer must make an affidavit on official Form No. 1, and forward the same to the Chief Inspector for comparison with Forms 7 and 9, required for use under the Act, and any delay in forwarding the affidavit will result in corresponding delay in final inspection before operation.

Inspectors will not be required to examine or finally pass new boilers built to registered designs until the provisions of this section have been complied with.

(f.) Each drawing must have on it a complete list of parts with identification numbers and all details shown, the material to be used and the dimensions of the parts being stated on the drawing and on the specification Form No. 7.

(g.) When a design is submitted and approved for the pressure required, it will be entered in the departmental register under a serial number, which number, together with the official approval stamp, will be placed on the blue-prints and specifications, one set of which will be returned to the person making the application for registration.

Any number of boilers can be built from this design until changes are made in the rules, when notice will be given to the person who submitted the design that within twelve months it should be made to comply with the changes. During this period the change or changes in the regulations shall not affect any registered design, but no boiler will be passed if built to this design after the expiration of the twelve months' notice, when the registered design will be cancelled.

Before the expiration of this period, however, designs may be submitted to replace the originals; these must be in conformity with the new amendments, and will be given new serial numbers with the prefix "A," and only half the scale fee will be charged for the new registration.

(h.) All designs submitted after change in the rules must comply with the new requirements:

(i.) When a design is submitted and not approved, it will be given a serial number, and a report on the same will be sent to the person by whom it was submitted, who must forward new blue-prints and specifications which will conform with the provisions of the Act; and when the design is finally passed it will be again reported on, and boilers can be built from this design as provided in subsections (e) and (g) of this section.

No fees will be charged for a second report, but if more than two reports have to be made on one design one-half the standard fee will be charged for each additional report.

(j.) Drawings or blue-prints submitted with applications for registration must be provided with a blank or white space 4 inches by 5 inches on which to place official approval stamp.

(k.) Changes made by manufacturers in designs already approved and registered will necessitate submission of new drawings and specifications, together with fees, in the same manner as if they were original designs.

(l.) Before commencing construction of any boiler which is to be built under inspection, the maker of such boiler must notify the Inspector of the district in whose jurisdiction it is to be built, giving him the number of the design, and stating when and where the materials can be tested, allowing the Inspector reasonable time to make the necessary arrangements for such tests.

If the provisions of this subsection are not complied with, the factor of safety of 1 may be added.

(m.) In cases where boilers, either new or second-hand, have not been built for operation under the jurisdiction of the Act, but are afterwards required for such purpose, complete drawings accompanied by the affidavit should be forwarded to the Chief Inspector of Machinery; but if information by drawings and affidavit from the manufacturer for good and valid reasons is not obtainable, the Inspector making the examination of the boiler shall be so informed, and he will add to the factor of safety as provided in section 7.

Should information be afterwards obtained which would justify giving the boiler a higher pressure, the Chief Inspector will communicate with the Inspector who made the examination, giving him the necessary instructions.

(n.) The fees for surveying designs of boilers and accessories for approval and registration shall be as follows:—

Cast-iron heating-boilers\$ 5 00

Vertical tubular boilers	5 00
Stills, steam-jacketed pans, and retorts ...	5 00
Vertical submerged tubular boiler	7 50
Return-tubular boiler	10 00
Internal furnace tubular boiler	10 00
Locomotive-type boiler	10 00
Water-tube boiler	10 00
Unclassified types of boilers	10 00
Single-cylinder non-condensing engines	5 00
Twin-cylinder non-condensing engines	5 00
Compound non-condensing engines	7 50
Single-cylinder condensing engines	7 50
Twin-cylinder condensing engines	7 50
Compound condensing engines	10 00
Unclassified types of engines	10 00
Oil-fuel piping and apparatus	5 00
Power-plant piping up to 500 horse-power..	5 00
Power-plant piping from 500 to 1,000 horse- power	7 50
Power-plant piping above 1,000 horse-power	10 00

Boiler accessories, such as safety-valves, main stop-valves, steam-gauges, blow-off cocks, water-gauge fittings, and test-cocks, for each design \$3.00.

Where it is necessary to have drawings submitted and approved for repairs or alterations on existing steam plants, a fee of \$5.00 will be charged.

If more than two reports have to be made on any one design, one-half the standard fee will be charged for each additional report.

IDENTIFICATION.

SEC. D. (a.) Every boiler built under these regulations shall be stamped on the boiler-plate in figures at least one-quarter of an inch in size in the place hereinafter indicated, as follows:—

- (1.) Builder's name and shop number of boiler:
- (2.) Provincial initial letters and registration number of design:
- (3.) Lowest tensile strength of any plate in the cylindrical shell of the boiler, with "S" for steel and "I" for iron:

(4.) The initials of the Engineer Surveyor who supervised the construction and tests of the boiler, with his serial number:

(5.) The date construction was completed, day of the month, numerical order of the month, last two figures of the year.

(b.) A sample stamping for British Columbia, stamped legibly and fully into a plate of the boiler itself (not the smoke-box), would be as follows:—

(1.) John Brown Co. (777) :

(2.) B.C. (555) :

(3.) 55,000. S. :

(4.) J.D. (472) :

(5.) 26.2.13.

(c.) When the boiler has not been built to a registered design, No. 2 space must be left blank; and when the boiler has not been built under inspection, No. 4 space must be left blank.

LOCATION OF STAMPING.

SEC. E. (a.) On horizontal return-tubular boilers, on right-hand side of the head above the rear arch-plate.

(b.) On portable and locomotive types, on right-hand side of fire-door clear of attachments.

(c.) On water-tube boilers, on end of steam-drum above manhole.

(d.) On internally fired boilers with circular furnaces, on right-hand side of fire-doors if practicable.

(e.) On vertical boilers, directly over fire-door.

(f.) The location of stamps must be indicated on the affidavit form.

MODE OF INSPECTION.

SEC. 1. The Inspector may, whenever he deems it necessary so to do, and he shall, at least once each year, examine every boiler in his district, and shall subject the same to a hydrostatic test in the ratio of 150 lbs. to 100 lbs. per square inch allowable as a working-pressure, using the water in such test at a temperature not exceeding 100° Fahr.;

provided, however, that such hydrostatic test may be omitted for reasons to be stated in the Inspector's report.

For the purpose of such test the owner or his agent shall provide the necessary pipe and fittings to connect the Inspector's pump with the boiler, and shall also provide men to fill the boiler with water, make all the joints, work the test-pump, and assist the Inspector in his examination of such boiler.

SEC. 2. Before the boiler is subjected to a test by hydrostatic pressure it shall be opened up for inspection, the manhole and mud-hole doors removed, the outside and inside of the boiler thoroughly cleaned, the furnace-grates removed, and all flues and tubes swept clean. The owners, or their agents, must see that the foregoing requirements are complied with before the arrival of the Inspector.

SEC. 3. In any case where defects are discovered, or in which the test is not satisfactory to the Inspector, the defects shall be made good and the boiler reinspected before a certificate is granted.

SEC. 4. If a boiler is too hot for an Inspector to make a thorough examination with safety and convenience, he shall decline to do so, and shall refuse to grant a certificate until he can make a satisfactory examination.

SEC. 5. Inspectors are to fix the working-pressure of boilers by a series of calculations of the strength of the various parts, and according to the workmanship and material of which they are composed, the strength of each part to be calculated by the formulæ given in these rules; if it occurs that there are parts of any type of boiler for which formulæ have not been provided in these rules, the case shall be submitted to the Chief Inspector, who shall furnish the formulæ for the calculation of the strength of such part or parts to the Inspector requesting the same.

SEC. 6. In order to satisfy himself as to the thickness of a plate, or the internal condition of a boiler, the Inspector may, should he deem it necessary, order holes to be cut in it, and may also

demand that such information, by drawing and specification of the several parts, be furnished him as will enable him to determine, by calculation and examination, their strength.

SEC. 7. In the event of satisfactory information not being obtainable, the Inspector shall use a factor of safety of 5, with such additions as his judgment may dictate.

SEC. 8. When boilers that have been placed in position are being inspected for the first time, the brickwork and covering shall be removed by the owner or his agent so that a thorough examination of the plates and rivet-joints can be made; such brickwork or covering, or any part of same, shall be removed at subsequent inspections upon the request of the Inspector.

SEC. 9. Inspectors, when inspecting, visiting, or examining boilers, shall see that the safety-valves, water-gauges, test-cocks, blow-off pipes, main steam-pipes, and all fittings and connections are in good order, sufficient in number, and that they comply with the requirements of the "Boilers Inspection Act."

SEC. 10. If an Inspector finds any defect in the boiler, or in any of the fittings, and such boiler has an unexpired certificate, he may suspend such certificate until repairs have been made, or in case of deficiency of proper fittings, until such deficiency has been supplied.

SEC. 11. If an Inspector is not fully satisfied that the safety-valves are in good working order, he shall test their efficiency under steam, the main steam-valve to be closed, the feed-water shut off, and the boiler steamed under full fires for at least fifteen minutes. If the accumulated pressure exceeds 10 per cent. of the loaded pressure, he shall not issue a certificate until the safety-valves have been brought within the above limit.

SEC. 12. Inspectors shall pay particular attention to the setting of return-tubular boilers. They must be supported in such a manner that excessive local stresses cannot be set up, and the general

arrangement must conform to the requirements of section 32 of the "Boilers Inspection Act."

(b.) The arched back connections should be cast segmental plates, in excess of a quarter-circle, with projections cast on the inside to hold the fireclay. They must be placed so that the vertical distance from the point of support on the back wall to the point of support on the boiler-head is at least 6" in excess of the horizontal distance between the boiler-head and the outer point of support on the back wall; as the greater the difference between the vertical and the horizontal line, the less will be the resistance to the expansion of the boiler, and the better the brickwork will stand.

(c.) Distances from the back head of return-tubular boilers to the back wall should be as follows:—

20 inches for boilers 30 inches to 42 inches diameter:

24 inches for boilers 44 inches to 60 inches diameter:

28 inches for boilers 64 inches to 72 inches diameter.

SEC. 13. Whenever any Inspector shall find it necessary, in conducting his investigations or in performance of any of his duties, to obtain the testimony from the Inspectors of other districts, he shall request the same through the Chief Inspector.

SEC. 14. Inspectors may act jointly or separately, but when a boiler has been inspected partly by one Inspector and the inspection is completed and the certificate issued by another, the latter, before issuing such certificate, shall obtain from the former Inspector who partially inspected such boiler his opinion as to what working-pressure should be allowed.

SEC. 15. When it comes to the knowledge of any Inspector that a steam-boiler is or has been carrying an excess of steam beyond that which is allowed by the certificate of inspection, he shall, in addition to reporting the fact to the Chief Inspector for prosecution under section 47 of the "Boilers Inspection Act," require the owner or owners of

such boiler to place thereon a lock-up valve of approved pattern that will prevent the carrying of an excess of steam.

CONSTRUCTION OF BOILERS.

SEC. 16. Every steel plate used in the construction of boilers (hereafter built) for operation under the "Boilers Inspection Act" shall be stamped by the makers with their name and the tensile strength of the plate.

SEC. 17. Steel plates are to be homogeneous, and made by the open-hearth or crucible processes, and having the following qualities:—

- (a.) Shell-plates not exposed to the direct heat of the fire or gases of combustion may have from 55,000 lbs. to 72,000 lbs. tensile strength; not less than 20% elongation in 8 inches; not over .04% phosphorus, and not over .04% sulphur:
- (b.) Shell-plates exposed to the heat of the fire or the gases of combustion, or plates on which flanging is to be done, may have from 55,000 lbs. to 67,000 lbs. tensile strength, and not less than 23% elongation in 8 inches:
- (c.) Fire-box plates to have from 55,000 lbs. to 65,000 lbs. tensile strength, and not less than 25% elongation in 8 inches:
- (d.) For all plates the elastic limit must be at least one-half the ultimate strength:
- (e.) Test strips are to be 8 inches long, planed or milled on the edges; the cross-sectional area not less than one-half of 1 square inch, and the width not less than the thickness of the plate:
- (f.) Steel up to $\frac{1}{2}$ inch thick must stand bending double and being hammered down on itself; above that thickness it must bend round a mandrel the diameter of which is one and a half times the thickness of the plate down to 180 degrees:

(g.) Bending test pieces to be in length not less than sixteen times the thickness of plate, with shear edges planed or filed off; other parts left rough.

SEC. 18. Rivets to be of good charcoal iron or of soft, mild steel, having the same physical properties as fire-box plates, and must test hot and cold by driving down on an anvil, the rivet being held in a tool, the head must flatten until its diameter is two and a half times the diameter of the shank (hot test), and one and a half times the diameter of the shank for cold test; all without developing cracks or flaws.

SEC. 19. Stay-bolts to be made of iron or mild steel manufactured for the purpose. For iron the tensile strength must be not less than 46,000 lbs.; the elastic limit not less than 26,000 lbs. and the elongation from 20 to 22% on 8-inch test piece.

For steel the tensile strength must be not less than 55,000 lbs.; the elastic limit not less than 33,000 lbs., and elongation from 22 to 25% on 8-inch test piece.

A bar taken at random, threaded with a sharp "V" thread die, must bend cold around a bar of the same diameter without showing any cracks or flaws.

SEC. 20. For braces and stays material must be similar to stay-bolt stock.

SEC. 21. Cast iron must be soft, grey texture, and high degree of ductility; it may be used for manhole plates, hand-hole plates, yokes, and nozzles, but its use for manhole rings, steam-domes, or like purposes is prohibited, it being an unreliable material when subjected to tensile strains.

SEC. 22. The Board consider that boilers well designed, well constructed, and made of good material should be allowed a higher working-pressure than boilers inferior in any of the above respects, and unless this is done the superior boiler is placed at a disadvantage, and good workmanship and the use of good material will be discouraged.

To provide for the above, they have adopted the

following rules regarding factors of safety for cylindrical boilers and cylindrical parts of boilers:—

When cylindrical shells of boilers are made of the best material (either iron or steel), with all holes drilled in place, the plates afterwards taken apart and the burrs removed, and all longitudinal seams fitted with double butt-straps, each at least five-eighths the thickness of the plates they cover, the seams being double-riveted with rivets having an allowance of not more than 75% over the single shear, and having the circumferential seams constructed so that the percentage is at least one-half that of the longitudinal seams, and provided that the boiler has been open for inspection during the whole period of construction, then 4 may be used as a factor of safety.

But when the above conditions have not been complied with the additions in the following scale must be added to the factor of safety, according to the circumstances of each case:—

- A .1 To be added when all holes are fair and good in the longitudinal seams, but drilled out of place after bending.
- B .2 To be added when all holes are fair and good in the longitudinal seams, but drilled before bending.
- C .2 To be added when all holes are fair and good in the longitudinal seams, but punched after bending.
- D .3 To be added when all holes are fair and good in the longitudinal seams, but punched before bending.
- E! .7 To be added when all holes are not fair and good in the longitudinal seams.
- F .07 To be added if the holes are all fair and good in the circumferential seams, but drilled out of place after bending.
- G .1 To be added if the holes are all fair and good in the circumferential seams, but drilled before bending.
- H .1 To be added if the holes are all fair and good in the circumferential seams, but punched after bending.

- I .15 To be added if the holes are all fair and good in the circumferential seams, but punched before bending.
- J! .15 To be added if the holes are not fair and good in the circumferential seams.
- K .2 To be added if double butt-straps are not fitted to the longitudinal seams, and the said seams are lap and double riveted.
- L .07 To be added if double butt-straps are not fitted to the longitudinal seams, and the said seams are lap and treble riveted.
- M .3 To be added if only single butt-straps are fitted to the longitudinal seams, and the said seams are double-riveted.
- N .15 To be added if only single butt-straps are fitted to the longitudinal seams, and the said seams are treble-riveted.
- O 1.0 To be added when any description of joint in the longitudinal seams is single-riveted.
- P .2 To be added if all holes are punched small, and afterwards drilled out in place.
- Q .4 To be added if the longitudinal seams are not properly crossed.
- R! .4 To be added when the material is in any way doubtful, and the Inspector is not satisfied that it is of the best quality.
- S 1.0 To be added if the boiler has not been open for inspection during the whole period of construction.

When marked ! the factor may be increased still further if the workmanship or material is such as, in the Inspector's judgment, renders such increase necessary.

SEC. 23. All rivet-holes must be made perfectly true and fair by clean-cutting punches or drills; the sharp edges and burrs are to be removed by slight counter-sinking and burr reaming.

SEC. 24. Drift-pins may be used with light hammers to pull the plates into position, but they are in no case to be used to enlarge or gouge holes with heavy hammers. Inspectors must pay particular attention to the manner in which drift-pins are used, and if it is found that they are being used

to enlarge or gouge holes they shall, in addition to requesting the discontinuance of the use of the pins, make such additions to the factor of safety as their judgment may dictate; and in the event of the continued use of drift-pins after the above request has been made, the Inspectors may refuse to issue a certificate for the boiler under consideration.

SEC. 25. Caulking is to be done by hand or pneumatic hammers and round-nosed tools; caulking edges are to be prepared by bevel planing, shearing, or chipping; the fit of the joint must be made in the laying of the plates, and excessive caulking avoided. Inspectors must see that the lower plate has not been nicked by caulking-tools.

SEC. 26. If steel rivets are used it is most important that they be uniformly heated throughout, and not at the points merely, as is the ordinary method of heating iron rivets; care should also be exercised regarding overheating, and they should never be hotter than a bright red; a thick fire with a moderate blast should be used to prevent burning. This is an important matter in the heating and using steel rivets, and should not be overlooked; if these precautions are not taken the rivet-joint is unreliable.

SEC. 27. The formulæ for ordinary chain-riveted and ordinary zigzag-riveted joints, and for joints of these descriptions when every alternate rivet is omitted in the outer or the outer and inner rows, will be found in Appendix A.

SEC. 28. The thickness of boiler-heads having a diameter up to 40 inches to be not less than $5/16$ inch; diameters from 40 inches to 52 inches, not less than $3/8$ inch; diameters from 52 inches to 60 inches, not less than $7/16$; and not less than $1/16$ additional thickness for every 8 inches additional diameter for boilers above 60 inches diameter. The front heads of all boilers above 42 inches diameter must have a manhole below the tubes, 10 inches by 15 inches, flanged inwards out of the solid plate, with a wrought-iron ring shrunk around the flange and faced off for the joint; if a manhole is to be cut in the back head above the tubes, it must be

10 inches by 15 inches, constructed in the same manner.

SEC. 29. Convex and concave heads do not need to be stayed when they are truly hemispherical; provided that the plate is thick enough to make it theoretically equal in strength to that of the cylindrical shell-sheets. For formulæ, see Appendix A.

SEC. 30. Dished heads must be stayed if they are theoretically equal to the pressure required, when considered as portions of spheres; the stays, however, if of iron, and not welded or worked in the fire, may be allowed a stress of 14,000 lbs. per square inch, or 10,000 lbs. when the stays have been welded or worked in the fire. If dished heads are not theoretically equal to the pressure required, they must be stayed the same as flat surfaces.

SEC. 31. The maximum stress allowable on stays, unless otherwise provided, shall be as follows:—

On steel stays not worked in the fire, 9,000 lbs. per square inch net sectional area; iron stays, not welded, 7,000 lbs. per square inch; and iron stays that have been welded, 6,000 lbs. per square inch.

(b.) When gusset-stays are used, their areas should be considerably in excess of that required for diagonal stays; gusset-stays must be properly fitted, the holes in them and in the angle bars must be reamed out when in place, and the angle bars must be placed so that the gusset-plate is a good fit between them; as diagonal stays can be used in most cases where gusset-stays can, they should be used in preference.

(c.) The most desirable and efficient method of fitting diagonal stays is to have a palm on one end riveted to the shell, having an aggregate rivet area of about 20 per cent. greater than the stay, if the rivets are in single shear; if, however, the ends are attached between two angle bars, the bolt or pin may have an area of 25 per cent. less than the stay, but the area of the rivets attaching the angle bars to the shell should be 20 per cent. greater than that of the stay; the other end of the stay should be screwed, and having nuts inside

and outside the boiler, with properly fitted bevel washers between the plate and the nuts; the ends of the stays should not be bent, and the stays should not be reduced in the body.

(c.) For finding areas, etc., for direct and diagonal stays, *see* Appendix A.

SEC. 32. When the tops of fire-boxes or of combustion boxes are flat, they must be supported by girders, properly fitted to the edges of the tube-plate and the back plate, or to the side plates, as the case may be, by chipping and filing, so that a good bearing may be effected on the edges of these sheets and also upon the flanged curve of the crown sheet.

A clear waterway between the crown sheet and the crown bars of at least 1 inch, and preferably $1\frac{1}{2}$ inches, should be allowed.

(b.) When the tops of fire-boxes or of combustion-boxes are curved, they should be stayed with radial stays, extending from the crown sheet to the outer sheet of the boiler; one row of stays should always be placed along the centre of the crown sheet, and care should be taken, in laying out the remainder of the holes, that the stays on either side of the centre row make equal angles with the vertical line, and they must also be placed at right angles to the surface to be supported; when the above precautions are taken this arrangement of stays has much to commend it.

SEC. 33. All boilers built or imported for use under the "Boilers Inspection Act" must be provided with spring-loaded safety-valves of an approved pattern, except as provided for heating boilers.

(b.) No lever safety-valve may be passed by Inspectors for use on existing boilers after such boilers have been removed from their present position, or reset; and in cases where lever safety-valves on existing boilers do not comply with the requirements of section 34 of the Act, they must be replaced by spring-loaded valves of an approved pattern.

(c.) The area of spring-loaded safety-valves must not be less than that given by Formula No. 30. *See* Appendix A, except for heating boilers (*see* special rule).

(d.) Single safety-valves may be used on boilers where the diameter does not exceed 3 inches, but where larger areas than the above are required, twin valves must be used; all valves must have a lift equal to one-eighth of their diameter, and the openings for the passage of steam to and from the valves, including the waste-steam pipe, must have an area at least equal to the total area of the valve or valves; each valve must also be fitted with lifting-gear, so arranged that it can be worked by hand from the boiler-fronts; the valve-seats must be secured in such a way that it is impossible for them to be raised with the valves.

SEC. 34. Spring-loaded safety-valves will be approved when the following conditions are complied with:—

- (1.) That twin valves be fitted to each boiler where the required area is above 7.06 square inches:
- (2.) That single valves be fitted to each boiler where the required area is not above 7.06 square inches:
- (3.) That the valves are of the size required by section 33:
- (4.) That the springs and valves are to be cased in, so that they cannot be easily tampered with:
- (5.) That provision is made to prevent the valves flying off in case of springs breaking:
- (6.) That lifting-gear is provided to ease all valves:
- (7.) That the springs have a sufficient number of coils to allow a compression under the working-load of one-eighth the diameter of the valve:
- (8.) That the valves are provided with metal stops or washers, against which the com-

pression - screws about when the loads sanctioned by the Inspector are on the valve.

SEC. 35. Manufacturers must submit safety-valve designs for approval and registration.

SEC. 36. Safety-valves are to be fitted to boilers as follows:—

They must be placed directly on the boiler-shell, and independent of any other steam-outlet; valves up to 2 inches diameter may be attached by riveting a reinforcing plate to the boiler-shell and tapping this plate to receive the valve; valves above 2 inches diameter must be attached by a cast-iron or steel nozzle riveted to the shell, with a suitable flange to which the valve must be bolted; Inspectors may require safety-valve discharge pipes to be led to the outside of the boiler-room.

SEC. 37. Each boiler must be fitted with a glass water-gauge, in such a way that the water-level inside the boiler can be determined by sight at all times, and that the gauge can be blown through from the top and bottom connection. Where the water-gauge cocks are not attached directly to the shell of the boiler, but to a column, shut-off valves must be fitted at the top and bottom of the column, and the lower connection between the boiler and the column must be kept as high up on the boiler as possible.

(b.) Each boiler must be fitted with at least two test-cocks; these should, where possible, be connected direct to the boiler, independent of the water-column.

(c.) All test-cocks and water-gauge cocks must be of a type that can be operated from the floor of the boiler-room without the use of a ladder.

SEC. 38. Each boiler must be provided with a correct steam - pressure gauge, such gauge to be placed so that it can be easily seen from the fire-room; all steam-gauges must have a siphon fitted between them and the boiler, and the siphon is at all times to be kept filled with water, so that the steam cannot come into contact with the tube inside the gauge.

SEC. 39. Inspectors must see that proper and efficient means are provided for lighting, so that the water-gauges and the steam-pressure gauges can be distinctly seen at all times.

SEC. 40. Each boiler must be provided with proper blow-off pipes and cocks; these are to be connected to the boiler at the lowest point; a reinforcing plate is to be riveted to the shell of the boiler, and the blow-off pipe or cock is to be attached to this plate; for externally fired boilers, such as return flue and return tubular, the blow-off connection must be made to the bottom of the shell, at the back end; substantial blow-off cocks must be provided.

SEC. 41. Each boiler must be provided with a separate feed-water arrangement, having a regulating-valve at the boiler-front; a stop-valve and a check-valve are to be fitted on the feed-pipe; the stop-valve is to be attached to the boiler-shell as follows: Valves up to 1 inch may be screwed direct to the shell, but for connections above this size a reinforcing plate must be riveted to the boiler-shell, and the stop-cock attached to this plate; the check-valve is to be placed next to the stop-cock.

The feed-water should be admitted to the boiler just below the water-line, at the coolest part, through an internal pipe where possible; feed-water must not be admitted to the boiler through the blow-off pipe, or near the parts of the boiler that are exposed to the direct heat of the fire.

SEC. 42. All boilers must be provided with stop-valves on every steam-outlet except safety-valve connections; these valves are to be fitted to the boiler-shell as follows: Steam-valves up to 1-inch diameter may be screwed direct to the boiler-shell; for valves from 1¼ inches to 2 inches, reinforcing plates must be riveted to the boiler-shell, and the valves may be screwed to these plates; valves above 2 inches diameter must be fitted to reinforcing plates by flanges; main steam stop-valves, if above 2 inches diameter, are to be connected to reinforcing plates by flanges and studs, or to steel or cast-

iron nozzles by bolts, such nozzles to be riveted to the boiler; flanges bolted to the boiler-shell or to the steam-dome will not be allowed.

SEC. 43. All manhole openings in the shells of cylindrical boilers must have their shorter axis placed longitudinally; the openings must be at least 10 inches by 15 inches in the clear, and they must be strengthened with reinforcing rings cut from the boiler-plate of the same thickness as the shell, and having at least the same sectional area as the part of the shell-plate which has been cut out; a flanged plate ring riveted on the inside of the manhole opening makes a good reinforcing ring for large boilers, but its use on small boilers obstructs the passage to the inside of the boiler.

SEC. 44. All boilers must be provided with sufficient mud-hole openings to properly clean every part of the inside of the boiler, and all such openings in the shells of cylindrical boilers, or the cylindrical parts of boilers, must have their shorter axis placed longitudinally. When mud-hole openings are threaded for plugs, the plugs must in all cases be of brass.

SEC. 45. The manhole and mud-hole doors should always be fitted inside the boiler; the bolts should be screwed through the door and riveted on the inside, having a shoulder or collar on the outside; there must not be less than two bolts in manhole doors.

SEC. 46. Every boiler, except otherwise provided, must be fitted with a fusible plug as follows: For return-flue boilers a plug must be placed in the back head, and another in one of the flues at the highest point; for return-tubular boilers a plug must be placed in the back head above the tubes; for locomotive-boilers a plug must be placed in the top of the fire-box; for marine type of boilers a plug must be placed in the top of the combustion-chamber, and for vertical boilers a plug must be placed in a special screwed tube at the lowest permissible water-level. Fusible plugs are to be filled with Banca tin, which must be renewed at least once a year.

SEC. 47. Low-water alarms of approved pattern may be used instead of fusible plugs, when the designs have been registered and approved.

SEC. 48. The neutral part of boiler-shells under steam-domes must be efficiently stayed; this may be done by stays from the shell to the top of the dome, with large well-bedded washers fitted under the nuts on the inside of the shell, and the upper ends of stays riveted to dome-head; the size of the stays should not be less than those for dished heads.

SEC. 49. All boiler-heads must be efficiently stayed for the required pressure; for particulars regarding stays, *see* section 31.

SEC. 50. All flat surfaces must be efficiently stayed for the pressure required, and in cases where direct-screwed stays are used, the diameter of such stays must not be less than $\frac{7}{8}$ inch.

SEC. 51. All steam-pipes and connections are to be carefully examined by the Inspectors at each inspection, and care must be taken to have such pipes fitted with proper and efficient arrangements for expansion. Inspectors shall subject all main steam-pipes to a hydrostatic test of twice the working-pressure of the boilers to which they are connected, at least once every four years, or as often during this period as in their judgment they may deem it necessary; provided, however, that the hydrostatic test to be applied to copper pipes shall not exceed one and a half times the working-pressure of the boilers to which they are connected; all main steam-pipes must be provided with efficient draining pipes and valves; all drain cocks and valves must be accessible, and so placed as to render it practicable to drain any portion of the steam-pipes or chests in connection therewith. It is advisable that the drains should be automatic in their action in all large steam plants.

SEC. 52. Inspectors are to examine all engines used in connection with steam plants, and take the main dimensions; particular attention must be given to fly-wheels, governors, and to the drainage of steam-chests, jackets, and cylinders.

SEC. 53. The tensile strength of cast iron in fly-wheel and belt-wheel rims may be assumed to be 10,000 lbs. per square inch and no more, on account of the difficulty in securing soundness in such castings; a factor of safety of 10 is to be used in calculating the strength of fly-wheels; this gives a maximum allowable strain in the rim of 1,000 lbs. per square inch, which corresponds to a rim velocity of 6,085 feet per minute, which is the maximum velocity allowable. Fly-wheels built in segments must have the flanges and bolts of the rim of sufficient strength to resist the force due to its velocity, and the flanges and bolts of the hub must be of sufficient strength to resist the force of keying to the shaft; the combined area of the bolts at each joint should be about $28/100$, the cross-section of the rim or hub, at that point, to be of equal strength.

SEC. 54. All engines with large and heavy fly-wheels should be provided with governors having an effective automatic stop, by which the steam is at once shut off from the cylinder in case of any failure of the driving attachments. And Inspectors may, where they deem it necessary, order such automatic stops to be provided.

SEC. 55. The cylinders, steam-chests, and steam-jackets of all steam-engines must be provided with proper and efficient drain pipes and cocks; in cases where the cylinders are steam-jacketed, the jacket drains must be automatic in their action; neglect of this important point has caused many serious accidents.

SEC. 56. At every annual inspection the Board desire and expect the Inspector to go inside the boiler and make a thorough examination of the sheets, rivets, rivet joints and stays, as well as all other parts of the boiler, and to make a complete and thorough hammer test; an Inspector may refuse to grant a certificate if he is unable to enter the boiler in consequence of the manhole being below the standard size (10 inches by 15 inches) or of the manhole being improperly placed, or if the stays are so placed that he cannot make a

proper examination of all parts of the boiler, until sufficient means of access to the boiler and all of its parts are provided. Excepting, however, in cases where the boiler is too small to admit of a standard manhole being cut, the Inspector shall require a sufficient number of hand-holes to be cut, so as to enable him to make as thorough an examination as possible from the outside; the hydrostatic test on such boilers must not be omitted.

SEC. 57. When an Inspector has to enter a boiler which it is possible to connect with another boiler containing steam, he shall, before doing so, request the owner or his agent to place a man at his disposal, to prevent the danger of steam being turned into the boiler which he enters, during the time he is inside it; and if this request is not granted, he may refuse to enter the boiler or to go on with the inspection, or he may insist on blank flanges being placed in the connecting pipes.

RULES FOR CONSTRUCTION AND INSTALLATION OF LOW-PRESSURE HEATING BOILERS.

SEC. 58. A design must be registered for every different type and for every different size of boiler, as provided in section C.

SEC. 59. (a.) An affidavit must be sent to the Chief Inspector of Machinery for every low-pressure heating boiler before it is installed.

(b.) Affidavit for cast-iron sectional boilers may be made by the manufacturers' duly authorized agent, when such agent is personally acquainted with the facts required to be established.

(c.) As blue-prints will have been submitted for registration of design, it will not be necessary to send in a blue-print with each affidavit.

(d.) If at any time the number of sections of a boiler which has been in operation and has passed inspection is increased, then another affidavit must be sent to the Chief Inspector, showing the additional number of sections.

SEC. 60. For purposes of identification, every heating boiler must be stamped as provided in sections D and E, except in the case of cast-iron

heating boilers, where the identification letters and numbers may be cast on the boiler-front, or stamped on a brass plate attached by screws to the boiler-front.

SEC. 61. Safety-valves for low-pressure heating boilers must be either of the spring-loaded or dead-weight type, and the designs must be approved and registered. The area required is .833 square inches per square foot of grate surface, and if the boiler requires a larger safety-valve than 3 inches in diameter (or 7.06 square inches area), then more than one valve must be used. Safety-valves for heating boilers may be attached to the boiler or pipes by either flanged or screwed connections.

SEC. 62. (a.) When steel boilers are designed for more than 30 lbs. working-pressure and are used for low-pressure heating purposes, the safety-valves for such boilers will be calculated by formulæ 30, 31, and 32.

(b.) When these boilers are connected with heating apparatus of a lower safe working-pressure than that allowable on the boiler, reducing-valves and safety-valves must be placed on main pipes leading to the heating apparatus, and the safety-valves must be of a total area equalling that of the pipe to which they are attached.

(c.) In cases where the pressure on these boilers is reduced to suit the working-pressure of the heating apparatus, then the extra safety-valves required may be placed either on the boiler or on the main steam-pipe. When they are placed on the main steam-pipe they must be between the boiler and the main stop-valve, and no valve must be fitted between the safety-valve and the boiler.

SEC. 63. When the heating plant consists of two or more boilers connected together, stop-valves must be placed as close to each boiler as possible on both the flow and return pipes, and check-valves may be placed on the return pipes close to the stop-valves, and on the farther side of these stop-valves from the boiler. (See Fig. 2.)

(a.) Equalizing pipe or pipes, not shown in Fig. 2, must be fitted between the flow and return pipes

to maintain the same water-level in all the boilers connected together.

SEC. 64. Where the heating plant consists of one boiler only, stop-valves may be placed as close to the boiler as possible on both flow and return pipes, and a check-valve may be placed on the return pipe close to the stop-valve, and on the farther side of

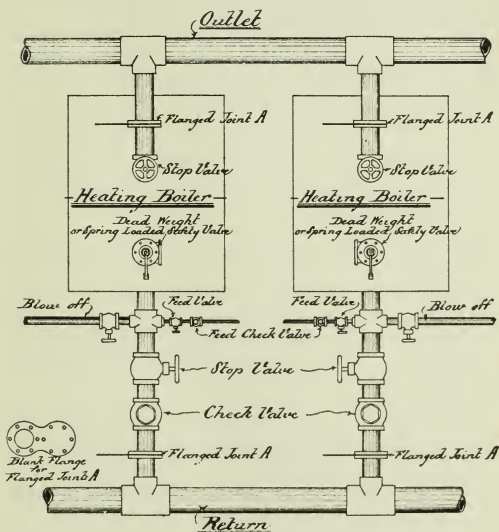


Fig 2

the stop-valve from the boiler. If a check-valve is used, stop-valves must be fitted on flow and return pipes.

SEC. 65. (a.) All flow and return pipes must have flanged connections for the purpose of inserting blank flanges, and a blank flange for each connection must be provided. (See Fig. 2.)

(b.) These flanged joints must be placed as follows: For flow-pipes, as close to the boiler as practicable, and on the farther side of the stop-valve from boiler, when such valves are used. (See Fig. 2.)

(c.) For return pipes, these flanges must be placed close to the valves, and on the sides of these valves which is farthest from the boiler. In no case must the flanged joints mentioned in this section be fitted between the boiler and the safety-valve, as the flange might, by oversight, be left in after testing the boiler. (See Fig. 2.)

SEC. 66. (a.) Blow-off cocks or valves may be placed either on the bottom of the boiler, or on the return pipe as close to the boiler as possible where the return pipe enters at the bottom of the boiler.

(b.) Blow-off cocks, when on the return pipe, must be placed between the boiler and the stop-valve. (See Fig. 2.)

SEC. 67. Extra feed-water may enter the boiler through the return pipe, and when this is the case it should enter the return pipe between the boiler and the stop-valve, and in every case the extra feed-pipe must be fitted with a regulating-valve and check-valve; the check-valve to be placed between the regulating-valve and the source of supply. (See Fig. 2.)

SEC. 68. (a.) Return pipes for externally fired return-tubular boilers may be carried through the combustion-chamber, and may be connected to the bottom of the boiler by means of screwing through the reinforcing plate and the boiler-shell in the same manner as blow-off pipes are attached; but as such pipes are subject to rapid deterioration due to the heat, the Department advise that return connection to these boilers should be made to the side of the boiler just below the water-line, having the brickwork arranged so that the products of combustion do not come in contact with the pipe.

(b.) In cases where return pipes are over 3 inches in diameter, they must enter the side of the boiler.

SEC. 69. No cast-iron heating boiler will be allowed to carry a working-pressure of more than 5 lbs., and they shall be subjected to a hydrostatic test of 50 lbs. per square inch by an Inspector before they are put into operation, and at least once a year thereafter.

For the purposes of inspection the owner must provide assistance to Inspectors when examining and testing the boilers, so as to make the examination complete.

SEC. 70. Fusible plugs must be fitted to cast-iron boilers in the heating surface above the fire, and as near to centre of fire-box as possible, unless otherwise directed by the Inspector.

SEC. 71. Steam-gauge pipes must be fitted with a tee having a cock or valve of $\frac{1}{4}$ -inch pipe size for the Inspectors' test-gauge, and in cases where boilers are not fed with water having a pressure of 50 lbs. to the square inch or over, a $\frac{3}{4}$ -inch pipe fitting must be provided for attaching the Inspectors' test-pump.

SEC. 72. In other respects than those specially mentioned in the sections referring to low-pressure heating boilers, they must comply with the general rules.

SEC. 73. Cast-iron radiators connected to low-pressure heating boilers must not be allowed a working-pressure exceeding 15 lbs. per square inch, and should be tested by hydrostatic pressure to 40 lbs. per square inch; provided, however, that radiators specially constructed for a higher pressure may be passed after designs have been submitted, together with a section for examination and test, and after the Inspection Department is fully satisfied that such special radiators are safe for the higher pressure required.

SEC. 74. All cast-iron boilers must be constructed to carry a safe working-pressure of 5 lbs. to the square inch, and must be made in such manner as to reduce, so far as possible, the internal stresses due to unequal cooling of the material during casting.

SEC. 75. In cases of dispute as to the strength or suitability of any type of cast-iron boiler before the design is finally rejected, the manufacturer may, at his own cost, deliver a section at the office of the Chief Inspector, or any other convenient place designated by him, for the purpose of testing it to destruction and for the thorough examination of the material.

SEC. 76. When installing steam-heating systems, care must be taken in placing the piping that the possibility of water-hammer be obviated, as this is particularly dangerous where cast-iron boilers and cast-iron radiators are used.

SEC. 77. In order to ensure safety in operation, care must be taken that there will be ample space between the boiler and the top of the boiler-room, and also between the boiler and the walls of the boiler-room, as well as between any pumps or other apparatus used in connection with the heating plant.

APPENDIX A.

RIVETED JOINTS.

The actual shearing strength of rivets is about five-sixths the tensile strength of the plates of the same material, but in iron boilers it is usual to assume the shearing strength of the rivets as being equal to the tensile strength of the plate; this being the case, the percentage strength of the joint may be found by the following formulæ; but in no case will more than 87% be allowed.

$$(1.) \frac{100 \times (p - d)}{p} = \% \text{ for iron or steel plates.}$$

$$(2.) \frac{100 \times A \times n \times c \times F}{4 \times p \times T} = \% 1 \text{ for iron plates with iron rivets.}$$

$$(3.) \frac{100 \times A \times n \times y \times c \times F}{4 \times y^1 \times p \times T} = \% 1 \text{ for steel plates with steel or iron rivets.}$$

The lowest of the values so found is the percentage strength of the joint to be taken.

$$(4.) \frac{A \times n \times c}{T} + d = p \text{ for iron plates and iron rivets.}$$

$$(5.) \frac{A \times n \times y \times c \times F}{4 \times y^1 \times T} + d = p \text{ for steel plates with iron or steel rivets.}$$

$$(6.) \frac{3 \times d}{2} = E \text{ for iron and steel plates.}$$

$$(7.) \frac{4d + 1}{2} = V \text{ for chain-riveted joints, iron or steel plates.}$$

$$(8.) \frac{\sqrt{(11p + 4d)(p + 4d)}}{10} = V \text{ for zigzag-riveted joints, iron and steel plates.}$$

$$(9.) \frac{6p + 4d}{10} = pD \text{ for iron and steel plates.}$$

BUTT-STRAPS.

When the number of rivets in the inner row is the same as in the outer—

$$(10.) \frac{5 \times T}{8} = Tl \text{ for double butt-straps.}$$

$$(11.) \frac{9 \times T}{8} = Tl \text{ for single butt-straps.}$$

Where the number of rivets in the inner row is double the number in the outer row—

$$(12.) \frac{5 \times T \times (p - d)}{8 \times (p - 2d)} = Tl \text{ for double butt-straps.}$$

$$(13.) \frac{9 \times T \times (p - d)}{8 \times (p - 2d)} = Tl \text{ for single butt-straps.}$$

Where—

- p = Pitch of rivets in inches.
- d = Diameter of rivets in inches.
- A = Area of one rivet in square inches.
- n = Number of rivets in one pitch (greatest pitch).
- pD = Diagonal pitch in inches.
- V = Distance between rows of rivets in inches.
- E = Distance from edge of plate to centre of rivet in inches.
- y = 8 for iron rivets and steel plates.
- y = 23 for steel plates and steel rivets.
- y¹ = 13 for iron rivets and steel plates.
- y¹ = 28 for steel rivets and steel plates.
- % = Percentage of plate left between rivets in greatest pitch.
- %1 = Percentage of rivet section as compared with solid plate.
- c = 1 for lap or butt-strap joints with single strap.
- c = 1.75 for double butt-strap joints.
- T = Thickness of plate in inches.
- Tl = Thickness of each butt-strap in inches.
- F = Factor of safety for shell-plates, according to section 22.

MAXIMUM PITCHES FOR RIVETED JOINTS.

$$(14.) (C \times T) + 1\frac{1}{2} = pM.$$

Where—

T = Thickness of plate in inches.

pM = Maximum pitch of rivets in inches, not to exceed 10 inches.

C = Constant applicable from the following table :—

Number of Rivets in one Pitch.	Constant for Lap Joints.	Constant for Double Butt-strap Joints.
1	1.31	1.75
2	2.62	3.50
3	3.47	4.63
4	4.14	5.52
5	...	6.00

When work is first-class such pitches may be adopted, so far as safety is concerned, yet, in some cases, it may not be well to adopt the greatest pitch found by the formula. The maximum pitch should not exceed 10 inches with the thickest plates for boiler-shells.

WORKING-PRESSURE FOR CYLINDRICAL SHELLS.

To determine the working-pressure to be allowed for cylindrical parts of boilers subjected to internal pressure :—

$$(15.) \frac{ts \times r \times 2T}{D \times F} = B.$$

Where—

ts = Tensile strength of plates.

T = Thickness of plate in inches.

D = Inside diameter of boiler in inches.

F = Factor of safety.

r = Lowest of the percentages divided by 100.

B = Working-pressure in pounds per square inch.

SEGMENTS OF BOILER-HEADS ABOVE OR BELOW TUBES TO BE SUPPORTED BY STAYS OR BRACES.

When the head is flanged and riveted to the shell, a portion of it becomes stiff enough to carry the boiler-pressure without depending upon the braces. The distance that thus becomes self-supporting may be determined by the following formula :—

(16.) The allowance for shell as stay to head to equal

$$= \frac{1}{2} \sqrt{\frac{125 \times (T+1)^2}{B}} + \text{radius of curvature of head flange.}$$

the allowance for tubes as stay to head to equal—

$$= \frac{1}{2} \sqrt{\frac{125 \times (T+1)^2}{B}} \text{ from centre of tubes.}$$

T = Thickness in sixteenths of inch. B = Working-pressure.

The area of a circular segment may be found by the following formula:—

$$(17.) \frac{h^3}{2c} + \frac{2c \times h}{3} = A.$$

Where—

h = Height of segment in inches.

c = Length of the chord of the segment in inches.

A = Area of the segment in square inches.

DIRECT AND DIAGONAL STAYS.

The pressure allowable on direct and diagonal stays may be found by the following formulæ:—

$$(18.) \frac{S \times a}{A} = B \text{ for direct stays.}$$

$$(19.) \frac{.7854 \times d^2 \times S \times L}{A \times H} = B \text{ for diagonal stays.}$$

Where—

A = Surface to be supported in square inches.

B = Working-pressure on boiler in pounds per square inch.

S = Working-stress per square inch net section of stay in pounds.

a = Area of direct stay in square inches.

d = Net diameter of stay in inches.

a₁ = Area of diagonal stay in inches.

L = Length of line drawn at right angles from the surface to be supported to end of diagonal stay.

H = Length of diagonal stay.

a₁ = Area required for direct stay to support the same surface.

$$(20.) \frac{a_1 \times H}{L} = a_1 \text{ for diagonal stays.}$$

TOPS OF FIRE-BOXES AND COMBUSTION-CHAMBERS
WHEN SUPPORTED BY RECTANGULAR GIRDERS.

$$(21.) \frac{30000 \times d^2 \times T}{D \times L \times (W - P)} = B \text{ for iron girders; if steel}$$

is used, the pressure can
be increased by adding 10%
to the constant.

Where—

W = Width of combustion-box in inches measured in the same direction as girder runs.

P = The distance of girder-stay from side of box in inches.

T = Thickness of girder in inches.

d = Depth of girder in inches.

L = Length of girder in inches.

D = Distance between girders from centre to centre in inches.

The pitches of the girder-stays must not be greater than those allowable for flat surfaces. (See Formula No. 22.)

PRESSURE ALLOWABLE ON FLAT SURFACES.

$$(22.) \frac{C \times (T+1)^2}{A} = B.$$

Where—

T = Thickness of plate in sixteenths of an inch.

A = Surface supported in square inches.

C = 125 for plates fitted with screwed stays, riveted heads.

C = 165 for plates fitted with screwed stays, nut outside.

C = 200 for plates fitted with screwed stays, double-nutted.

C = 290 when doubling plates same thickness as heads are fitted.

A is to be determined by the following formula:—

$$(23.) \frac{P_1^2 + P_2^2}{2} = A \text{ where pitches are regular;}$$

$$\text{or } \frac{(pD_1 + pD_2)^2}{8} = A \text{ where pitches are irregular.}$$

Where—

P_1 = Pitch of stays in inches.

P_2 = Distance between rows of stays in inches.

pD = Diagonal pitch.

A = Area to be supported.

CONVEX HEADS.

The pressure allowable on convex heads, when they are truly hemispherical, may be found by the following formula:—

$$(24.) \frac{ts \times r \times 4T}{D \times F} = B.$$

The pressure allowable on concave hemispherical heads may be found by the following formula:—

$$(25.) \frac{ts \times r \times 4T \times .6}{D \times F} = B.$$

COMPRESSIVE STRESS ON TUBE-PLATES.

$$(26.) \frac{(D - d) \times T \times 20000}{W \times D} = B.$$

Where—

D = Least horizontal distance between centres of tubes in inches.

d = Inside diameter of ordinary tubes in inches.

T = Thickness of tube-plate in inches.

W = Extreme width of combustion-box in inches from front of tube-plate to back of box.

PRESSURE ALLOWABLE ON PLAIN CIRCULAR FURNACES MADE OF STEEL PLATES.

$$(27.) \frac{C \times T^2}{(L + 1) \times D} = B.$$

Where—

D = Outside diameter of furnace in inches.

T = Thickness of plate in inches.

L = Length of furnace in feet, or length between rings.

B = Working-pressure per square inch, which must not exceed that found by the limiting formula, as follows:—

$$(28.) \frac{10000 \times T}{D} = B.$$

C = Constant according to the following circumstances:—

Furnaces with butt joints and drilled holes :—

112500 where the longitudinal seams are double-riveted and fitted with single butt-straps.

100000 where the longitudinal seam is single-riveted and fitted with single butt-strap.

112500 where the longitudinal seam is single-riveted and fitted with double butt-straps, or where seam is welded.

Furnaces with butt joints and punched rivet-holes :—

106250 where the longitudinal seam is double-riveted and fitted with single butt-strap.

93650 where the longitudinal seam is single-riveted and fitted with single butt-strap.

106250 where the longitudinal seam is single-riveted and fitted with double butt-strap.

Furnaces with lap joints and drilled rivet-holes :—

96000 where the longitudinal seams are double-riveted.

87500 where the longitudinal seams are single-riveted.

Furnaces with lap joints and punched rivet-holes :—

90000 where longitudinal seams are double-riveted.

78000 where longitudinal seams are single-riveted.

PRESSURE ALLOWABLE ON CORRUGATED FURNACES.

$$(29.) \frac{14000 \times T}{D} = B \text{ for steel furnaces.}$$

Where—

T = Thickness in inches.

D = Outside diameter in inches, measured at the bottom of the corrugations.

SAFETY-VALVES.

The safety-valve area for any boiler may be found by the following formula :—

$$(30.) \frac{37.5}{G_p} \times a = A, \text{ or } .833 \times a = A \text{ for low-pressure heating boilers;}$$

$$\text{or } \frac{37.5}{G_p} \times \frac{E}{200} = A \text{ where oil fuel is used.}$$

Where—

a = Area of grate surface in square feet.

Gp = Gross pressure = boiler-pressure + 15.

E = Total evaporation of water in lbs. per hour.

A = Required safety-valve area in square inches.

The size of steel for safety-valve springs may be found by the following formula :—

$$(31.) \sqrt[3]{\frac{s \times D}{C}} = d.$$

Where—

s = The load on the spring in pounds.

D = The diameter of the spring in inches from centre to centre of wire.

d = The diameter, or side of square, of wire in inches.

C = 8000 for round steel.

C = 11000 for square steel.

The pressure or load on a safety-valve due to the spring may be found by the following formula :—

$$(32.) \frac{d^3 \times C}{D} = s.$$

Where—

d = Diameter of wire in inches.

D = Diameter of spring in inches from centre to centre of wire.

s = Load on spring in pounds.

STRENGTH OF FLY-WHEELS.

$$(33.) S = .0010656 \times R^2 \times N^2.$$

Where—

S = Strain per square inch of sectional area of rim.

R = Radius in feet from centre of gravity of rim to centre of shaft.

N = Number of revolutions per minute.

NOMINAL HORSE-POWER.

The nominal horse-power of boilers, or of steam plants, for the rating of fees and engineers' certificates, is to be calculated by the following formula :—

$$(34.) \frac{H_s}{15} = H_p.$$

Where—

H_s = Total heating surface in square feet.

H_p = Horse-power (nominal).

THOS. TAYLOR,
Minister of Public Works

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